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AGS Studies Report

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Subject Vertical Chromaticity Study at 4.5 GeV/c in the AGS

We carried out a study that involved varying the ring sextupole magnets and measuring the resulting AGS chromaticity. The purpose of this test was to study the range of change available without affecting beam loss and beam size. We had seen large losses during the polarized proton run when attempting sextupole adjustment. It is thought that changing the AGS chromaticity during the fast tune jumps needed for polarized proton running could lead to needing less tune jump (see Appendix). The present experiment saw losses only when the tune spread in the beam became reasonably excessive. The study was done at a beam intensity of 3×10^{12} protons per pulse.

Figure 1 is a plot of the vertical tune as a function of radius and sextupole current at 8960 GCC (position of the $G\gamma = \nu$ polarized proton resonance). No changes were made to the horizontal sextupoles and the horizontal chromaticity was not measured. It appears that the radial pivot point and the vertical tune at that point are different for + and - sextupole currents. We do not understand this.

Figure 2 is a plot of the chromaticity as a function of current. The radial extremes were used for this plot. However, using other fits to the data does not significantly change this plot.

The tune measurements ignored the coupling between the horizontal and vertical planes which distorts the measure when the tunes cross, but is not important when they are very different. The radial measure was an average of the full set of horizontal PUEs. A revolution frequency measurement which would confirm this measure must be taken at fixed field and this was not done.

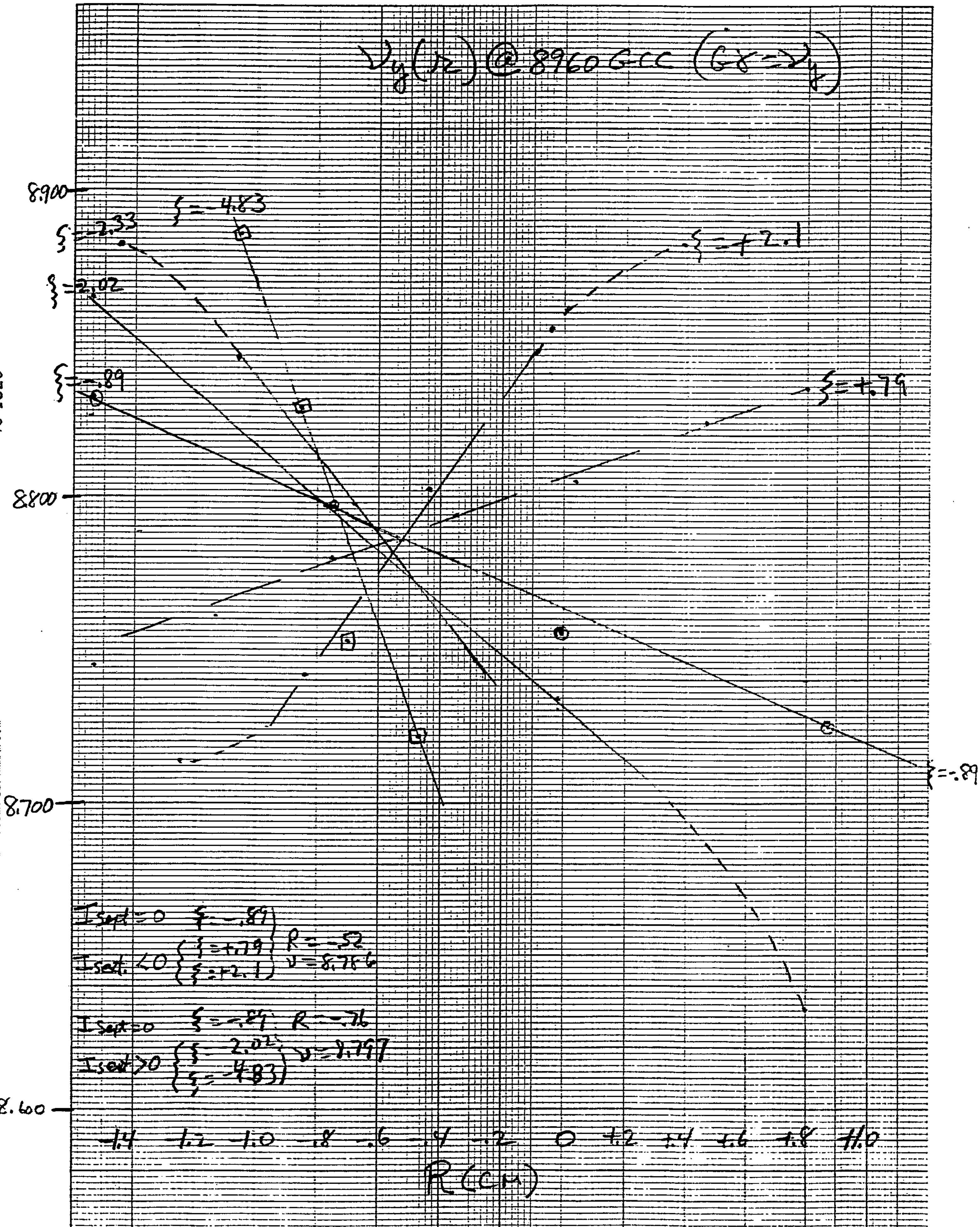
νy(R) @ 8960 GCC (Gγ = νy)
8900
8800
8.700
8.600
ξ = -2.33
ξ = -4.83
ξ = 2.02
ξ = -.89
ξ = +2.1
ξ = +.79
ξ = -.89
I sept = 0 ξ = -.89
I sept. < 0 ξ = +.79 ξ = +2.1
R = -.52
ν = 8.786
I sept = 0 ξ = -.89 R = -.76
I sept > 0 ξ = -2.02 ξ = -4.83
ν = 8.797
-1.4 -1.2 -1.0 -.8 -.6 -.4 -.2 0 +.2 +.4 +.6 +.8 +1.0
R (CM)

FIG. 1

VERTICAL CHROMATICITY AT Gγ=ν (8960Gcc)

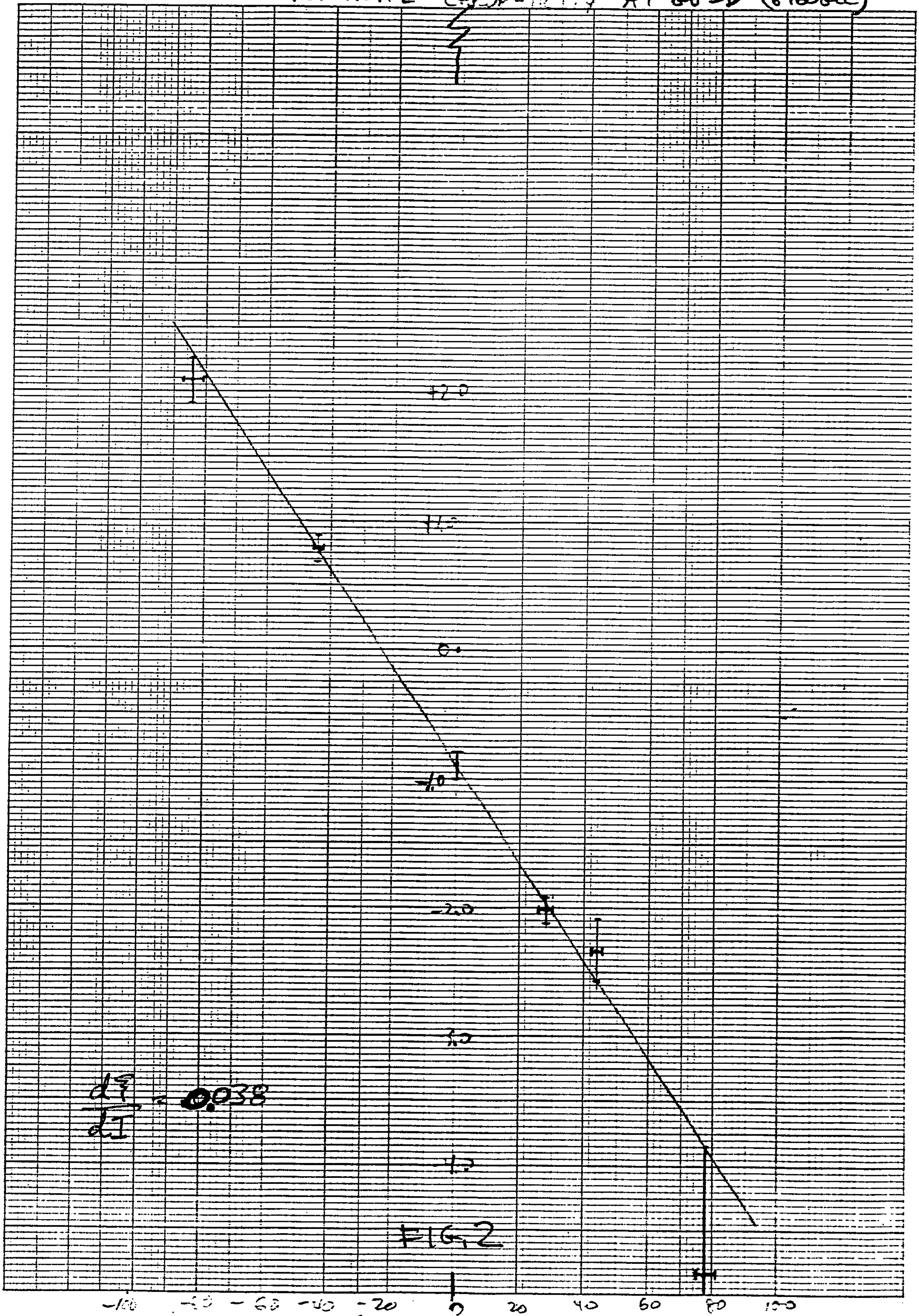

FIG. 2

Appendix

The condition for an intrinsic depolarizing resonance is $G\gamma = kn \pm \nu$, where $G = 1.79$, $\gamma = E/m$, $K = 12$ (for AGS), n = integer, and ν = vertical tune. Because of energy spread in the beam, this condition is not normally satisfied for all particles simultaneously. Let (p_o, γ_o, ν_o) refer to the particle at the center of the beam momentum distribution. Consider the off-momentum particle whose momentum is $p = p_o + \Delta p$, $\gamma = \gamma_o + \Delta\gamma$, $\nu = \nu_o + \Delta\nu$. For relativistic particles $\Delta\gamma/\gamma = \Delta p/p$ and by definition of chromaticity $\Delta\nu/\nu = \xi\, \Delta p/p$.

Now for this off-momentum particle, the two sides of the resonance condition become:

$$G\gamma \to G\gamma_o + G\Delta\gamma = G\gamma_o + G\gamma_o \frac{\Delta p}{p}$$

$$kn \pm \nu \to kn \pm \nu_o \pm \nu\, \xi \frac{\Delta p}{p} .$$

If these changes are equal, this particle will hit the resonance simultaneously with the on-momentum particle, a situation which makes resonance jumping most effective since the jump occurs at the same time for all the particles.

The change will be equal if:

$$G\gamma_o \frac{\Delta p}{p} = \pm \nu_o\, \xi \frac{\Delta p}{p} ,$$

a condition independent of $\Delta p/p$ and met for

$$\xi = \mp \frac{G\gamma_o}{\nu_o} .$$

In particular for $G\gamma = 0 + \nu$, $\xi = +1$ and for $G\gamma = 36 - \nu$, $\xi = -3.1$ ($\nu \sim 8.75$).